Contents

DROUGHT OCCURRENCE AND ITS IMPACTS IN VIET NAM

Drought situation in Viet Nam

Viet Nam lies in the tropical zone of the Northern-hemisphere, with a coastline of approximately 3,000km. The country is prone to almost all kinds of natural disasters, of which storms, floods and drought rank as the worst and most frequent, inflicting substantial human suffering, massive environmental, social and economic damages, and immense agricultural production losses.

Though Viet Nam has an abundant rainfall, this water source is not distributed well throughout the country. Rainfall distribution is considerably uneven within one year and differs from region to region within the country. From the north to the south, seasons approach each region (north, central and south) one month later than their previous destinations. Rainfall during the rainy season is five to six folds bigger than that of the dry season, accounting for 75- 85% of the total annual rainfall (May- June to October- November) on the average. The limited water supply during the remaining six months of the dry season fails to satisfy agricultural production and humans' demand.

The disparity between seasonal rainfall is also heavily determined by topographical features. In eastern mountain slopes, rainfall level amounts to 2,000- 3,000mm/ year on average. By contrast, rainfall is low in hidden river valleys. In the coastal provinces, sea water and salinity intrusion exacerbate the water shortage problems. In addition, water flow in rivers and smaller streams during rainy season accounts for 70-80% that of the whole year whereas during the remaining months and the limited rainfall years, it is 2-3 times less than that.

Parts of the country, especially the northern delta and the southern Mekong Delta, are classified as suffering from water shortage, if only internal water resources are taken into account, i.e., river water and underground water.

In the recent years, many provinces face water shortages and drought, which are becoming frequent catastrophe, with an imminent threat of desertification, in the form of sand burying farmland especially in the coastal sandy areas. The global climate changes coupled with over crowdedness (population explosion) in urban areas, which takes heavy toll on existing limited water sources, and impacts of unplanned or planned but poorly executed development schemes are contributing to increased threat of droughts in various parts of Viet Nam.

Impacts of Drought and Desertification in Viet Nam

Viet Nam's main economy comes from its agricultural products. Some 80% of Viet Nam's population works in the agriculture sector. With the agricultural production depending very much on rain-fed water sources in the country, uneven distribution of water sources and slight climate changes can have great impact on the country's economy, be it floods or drought.

In terms of drought, from 1960 to 1998 (39 years), following occurrences were recorded:

- Winter- spring crops (January- February- March) were stricken by serious drought in 1959, 1961, 1970, 1984, 1986, 1989, 1993 and 1998 (8 years).

- The north had its June- July- August crops hit by drought in 1960, 1961, 1963 and 1964 (4 years)
- The central highlands and the south suffer drought in 1983, 1987, 1988, 1990, 1992 and 1993 (6 years).
- Drought occurred on a national scale in 1988, 1993 and 1998.
- Between 1976 and 1998, serious large scale drought hit 11 winter- spring crops, inflicting catastrophic damages.

Social consequences of drought in Viet Nam greatly affected people's minimum water demand. The nation-wide drought in 1998 affect about 3.1million people, particularly in central part of the country, the central highlands and southern provinces, who faced lack of water, caused massive animal death and environmental severity, with damages totaling over VND 5,000 billion.

Drought in Mekong Delta.

The Mekong Delta has nearly 4 million ha of natural land, of which 2.9 million ha is farmland, which accounts for the around 2 million ha of rice production zone, the largest in the country. Major economic activities include production of agricultural (rice and fruits) and maritime goods.

The topography of Mekong Delta is flat with a dense canal network, which is strongly influenced by the annual floods of the Mekong River. Due to its favorable climatic features, the Mekong Delta has a year round crop regime. However, Mekong floods arriving late or ending early can lead to large scale drought problems in the Delta. In addition, the main water flow of the Mekong River in the dry season is rather small and its water level is low. Seawater intrudes deeply inland, sometimes as far as 40- 50 km from the sea, which has serious adverse effects on rice and fruit trees.

Historically, serious drought ravaged the region from April to June of 1983, 1992, 1998, and from October to December of 1958 and 1992. According to agricultural production statistics since 1980, the severe Mekong Delta droughts are recorded as follows:

- Winter-spring drought: in 1989, 1992, 1993 and 1998.
- Summer-autumn drought: continuously from 1981 to 1998.
- Summer drought: in 1981, 1983, 1984, 1985, 1987, 1992, 1994 and 1998.

Drought during these years affected 4,000 to nearly 230,000ha of farmland, and entirely destroyed 1,000 to 390,000ha. The winter- spring and summer- autumn drought in 1998 caused shortage of water for 1,100,000 people, affected nearly 274,850ha of summer- autumn crop area and destroyed over 32,000 ha.

Therefore, an effective and comprehensive hydro-meteorological disaster management plan is required in this region, as the one of the key economic zones of the nation, to preserve and sustain its resources and richness.

1. WHAT IS DROUGHT?

Drought can be defined based on differences in regions, needs, and disciplinary perspectives. In some regions, drought is a normal, recurrent feature of climate. In some, drought can be defined as a prolonged, abnormally dry period. For example, we might define drought in Libya as occurring when annual rainfall is less than 180 mm, but in Bali, drought might be considered to occur after a period of only 6 days without rain. In the most general sense, drought originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector and for users' normal needs.

Drought differs from other natural hazards, such as floods, tropical cyclones and earthquakes, in following ways:

- Its effects often accumulate slowly over a considerable period of time;
- The onset and end of drought is difficult to determine;
- Lack of a precise and universally accepted definition of drought;
- Drought impacts are non-structural and spread over a larger geographical area than damages result from other hazards.

2. DIFFERENT TYPES OF DROUGHT

Meteorological drought is usually associated with significant decrease in normal precipitation over an area and expressed solely on the basis of the degree of dryness (often in comparison to some normal or average amount) and the duration of the dry period. Meteorological drought definitions are region specific. In India, meteorological drought is defined as occurring when the seasonal rainfall received over an area is less than 75% of its long term average value. In Philippines, a locality is declared to be suffering (meteorological) drought when rainfall is 40% below the average for 3 successive months, compared to previous monthly rainfall statistics for that locality.

Hydrological drought refers to marked depletion of surface water (rivers, lakes, streams and reservoirs) and fall in water tables. Frequency and severity of hydrological drought is often defined on a watershed or river basin scale. If the actual flow for a selected time period falls below a certain threshold, then hydrological drought is considered to be in progress.

Agricultural drought occurs when there is not enough soil moisture and rainfall inadequate to support crops. It is the impact of meteorological and hydrological droughts on crop, with insufficient moisture to maintain average plant growth and yields. The impact of agricultural drought is difficult to measure due to complexity of crop growth, and the possible presence of other factors such as pests, weeds, low soil quality and low prices.

3. CAUSES OF DROUGHT

The main cause of drought is lack of rain over a long period of time, such as a few weeks, a season or a year. Drought is associated with major climate factors such as precipitation, temperature and movement of air. A decreased frequency of precipitation and anomalies in

precipitations are linked to higher than (summer drought) or lower than (winter drought) normal surface-air temperatures.

In general, drought is caused by failure or erratic behavior of monsoon and its effects can be aggravated by the following factors:

- Overexploitation of surface and ground water.
- Inadequate water conservation measures.
- Depletion in forest cover.
- Shifting of agricultural practices (low to moderate water demand crops to high water demand crops).
- Limited irrigation facilities.
- Poor water management practices at Household and Farm level.
- Climate change phenomenon caused by increased emission of certain gases (*such as carbon dioxide (CO_2), water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), chloroflourocarbons (CFCs), and ozone (O_3))* leading to the rise in temperature.
- Occurrence of extreme climate events (e.g., El Nino and La Nina).
- Intensified competition for water resources due to growing population, uncertain reserved water rights and aging urban water infrastructure.

4. DROUGHT IMPACTS

Drought severity is dependent not only on the duration, intensity and geographical extent of a specific drought period, but also on the demands made by human activities and vegetation on a region's water supplies. The impact of drought is widespread and includes disruption of cropping programs, reduction of livestock, and subsequent threats posed to erosion of the capital and resource base of farming enterprises. The risk of serious environmental damage, particularly through vegetation loss and soil erosion, has long term implications for the sustainability of agricultural industries. Moreover, the occurrence of bushfires and dust-storms often increase during dry times.

4.1 Drought Impacts

When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water (also on surface and sub-surface water supplies), which can be rapidly depleted during extended dry periods. Usually, during drought, soil water reserves are replenished first, followed by stream-flow, reservoirs and lakes, and ground water. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (i.e., reservoirs and lakes) and subsurface water (i.e., ground water), for example, are usually the last to be affected.

In the after drought period, ground water users, often the last to be affected by drought during its onset, may be last to experience a return to normal water levels. The length of the recovery period is a function of the intensity of the drought, its duration, and the quantity of precipitation received as the episode terminates.

The impacts of drought can be generally divided into three major groups: Economic Impacts, Environmental Impacts and Social Impacts.

4.1.1 Economic Impacts

General economic impacts include:

- Decreased land prices
- Loss to industries directly dependent on agricultural production (e.g., machinery and fertilizer manufacturers, food processors, dairies, etc.)
- Unemployment from drought-related declines in production
- Strain on financial institutions (foreclosures, more credit risk, capital shortfalls)
- Revenue losses to federal, state, and local governments (from reduced tax base)
- Reduction of economic development
- Fewer agricultural producers (due to bankruptcies, new occupations)
- Rural population loss

The following table indicates the impacts of drought on crucial production and supplies sectors within a country, in terms of long term negative economic effects.

Sector	Impacts
Agriculture	• Annual and perennial crop losses • Damage to crop quality • Income loss for farmers due to reduced crop yields • Reduced productivity of cropland (wind erosion, long-term loss of organic matter, reduced land carrying capacity, etc.) • Insect infestation causing plant disease • Increased irrigation costs • Cost of new or supplemental water resource development (wells, dams, pipelines)
Livestock production	• Reduced productivity • Reduced milk production • High Cost of new or supplemental water resource development (wells, dams, pipelines) for livestock • High cost/unavailability of feed for livestock including increased feed transportation costs • High livestock mortality rates and decreased stock weights • Disruption of reproduction cycles (delayed breeding, more miscarriages) • Possibility of range fires
Energy	• Increased energy demand and reduced supply because of drought-related power curtailments • Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power
Timber production	• Loss of prime forest lands due to wild fires • Tree disease • Insect infestation • Impaired productivity of forest land

	• Direct loss of trees, especially young ones
Fishery	• Damage to fish habitat • Loss of fish and other aquatic organisms due to decreased flows
Recreation & tourism	• Loss to manufacturers and sellers of recreational equipment • Losses related to curtailed activities: hunting and fishing, bird watching, boating, etc.
Water supply	• Revenue shortfalls • Cost of water transport or transfer (for various usage and individual consumption) • Cost of new or supplemental water resource development
Transportation	• Loss from impaired navigability of streams, rivers, and canals
Food production & supply	• Food shortage due to low production yield (agriculture sector, aquaculture sector, etc.) • Increase in food prices • Higher cost for importation of food

4.1.2 Environmental Impacts

Environmental losses are the result of damages to plant and animal species, wildlife habitat, and air, soil and water quality. Some of the effects are short-term and conditions quickly return to normal following the end of drought. Other effects linger for some time or may even become permanent. They are mainly caused by:

- Increased number and severity of fires - forest fires destroying thousands of acres of lands, urban and rural fires exacerbated by the lack of water to distinguish the fires, etc.
- Haze caused by fires, affecting air quality and reduced visibility - due to excessive presence of dusts and pollutants, exacerbated by reduced fire fighting capability (lack of water)
- Wind erosion of soils
- Desertification[1]
- Reduction and degradation of fish and wildlife habitat due to lack of feed and drinking water, disease and increased vulnerability to predation (species concentrated near water)
- Migration and concentration of wild animals - loss of wildlife in some areas and too many wildlife in other areas
- Damage to plant species due to lack of water and plant diseases.

In additional, severe hydrological effects can be detected in lowered water levels in reservoirs, lakes and ponds and reduced stream-flow and springs. Loss of wetlands in turn leads to loss of biodiversity and fish habitats. Drying up of estuaries trigger changes in salinity levels. The increased groundwater depletion produce land subsidence and ultimately impact on the quality of water (e.g., salt concentration, increased water temperature, rising PH level, turbidity).

[1] Desertification occurs when vegetation is stripped from the land, the surface dries out and reflects more of the sun's heat. This would alter the thermal dynamics of the atmosphere and suppress rainfall, which would, in turn, dry out more land.

4.1.3 Social Impacts

Social impacts mainly involve public safety, health, conflict between water users, reduced quality of life and inequities in the distribution of impacts and disaster relief. Many of the impacts specified as economic and environmental have social components as well. In general, social impacts can be further subdivided into four major areas as shown in the table below.

Key areas	Impacts
Health	• Mental and physical stress (anxiety, depression, loss of security, domestic violence) • Health-related low-flow problems (cross-connection contamination of drinking water sources, diminished sewage flows, increased pollutant concentrations, decreased quality of water, etc.) • Reductions in nutrition (high-cost food limitations, stress-related dietary deficiencies) • Loss of human life (heat stroke, malnutrition) • Loss of animals' lives (malnutrition, shortage of fodder, outbreak of disease caused by wildlife concentrations, other infections like worms) • Public safety from forest and range fires (increased respiratory ailments from smokes and haze, increased pollutants in the air) • Famine (food shortage caused by low production yield, spread of disease to animals and plants, locust invasion)
Conflicts	• Water user conflicts (upstream vs. downstream, rich vs. poor, rural vs. urban) • Political conflicts (e.g., inequality in drought response, inefficiency in handling drought management, withholding of information) • Management conflicts (mainly related to political conflicts) • Other social conflicts (e.g., scientific, media-based)
Quality of life/ changes in lifestyle	• Disruption of cultural belief systems (e.g., religious and scientific views of natural hazards) • Loss of cultural sites and other important landmarks (loss of aesthetic values) • Increased poverty in general (e.g., mounting debts for the poor, increased credit risks, increased rural unemployment) • Mass migrations (rural to urban areas, cross-border migrations) • Reduction or modification of recreational activities (decreased incomes, lesser choice of recreational activities)
Drought response	• Perceptions of inequity in relief distribution, possibly related to socioeconomic status, ethnicity, age, gender, seniority • Lack of data/information • Lack of coordination and dissemination • Loss of confidence in government

5. DROUGHT MONITORING

Drought is a slow onset disaster and can be predicted from a series of meteorologic, agricultural, political and/or economic indicators that may be monitored continuously.

Several properly planned and implemented preparedness activities can decrease the impact of droughts on human settlements.
Historically, droughts have tended to occur at regular and predictable intervals. Therefore, it is helpful to compile historical records of drought so that drought forecasting can be made more accurate. Whether precisely predictable or not, the historical trends can give an indication as to when drought periods might be expected.

In establishing a drought monitoring system, it should be based on simple information that non-technical observers can easily acquire and transmit, i.e., based on indicators. Among the normal indicators of the onset of a drought are:

- an unusual dry period;
- an increased number of wind storms;
- an increased number of dust storms (caused by loss of soil moisture);
- low air temperature and increased day time temperature;
- diminishing water supplies and reduced stream-flow conditions (lower reservoir level, surface water and ground water levels);
- an increase in the death rate of animals;
- changes in vegetation, especially the introduction of desert plants such as scrub brushes;
- unusual or unseasonal changes in the prevalence rates of specific communicable diseases associated with personal and environmental hygiene, indicating the diminished use of water for washing.
- In areas with a long history of drought occurrence, lower than normal precipitation can be taken as a potential drought sign.

In issuing drought warnings, it is important to have a classification system for levels of drought severity such as first stage, severe, extreme, and exceptional. Drought severity and impacts differ at different areas and such system will help the decision makers and the community living in the drought prone areas to take appropriate actions.

6. DROUGHT SURVIVAL TIPS

6.1 Before drought

The general measures that can be practiced at the local level include:

- Seeking up-to-date drought forecast generated by the reliable source (state agencies).
- Obtaining drought insurance.
- Installation of rain gauges in drought prone areas for rainfall monitoring.
- Monitoring drought indicators and dissemination of warning as soon as the signs for drought are detected.

Specific measures that can be taken to prepare for a drought are described below:

Managing the food reserve

- Develop village grain banks.
- Identify mechanisms that will facilitate sharing of resources with other communities.

- Construct and maintain storage areas with natural cooling effects that can keep critical food reserve over a long period of time.
- Develop a plan within the community for food distribution in case of a drought, based on criteria (e.g., number of members in a family, the average income of a family, etc.), agreed upon by the community.

Managing the water needs

- Examine the water use efficiency and irrigation needs.
- Clean up the irrigation channels and routes to facilitate maximum flow and to prevent blockage.
- Determine the potential water demands.
- Locate the nearest natural water sources.
- Save rainwater from roofs in cisterns and rain barrels.

Seeds storage

- Purchase of local seed stocks.
- Establishment of seed banks at various drought prone locations.

Potential Alternative livelihoods

- Consider alternative on-farm related businesses. Diversification can be a good long-term approach to revenue shortfalls from drought. Some potential businesses include:
  - Growing alternative crops and plants (that require less water usage)
  - Alternative livestock (that require less water consumption)
  - Home-based enterprises including sewing projects, crafts, catering services, etc.

Managing livestock

Effects of drought include a shortage of forage, a shortage of stockwater, or both. The survival of livestock depends on the availability of pasture land and the following is a check list that may help the livestock producers in preparing for drought.

- Keep up-to-date fodder inventories.
- Set up livestock centres to ensure survival of at least a breeding nucleus stock.
- Reduce stocking levels to balance livestock needs with the forage supply.
- Distribute cattle across more fields in those areas where rangelands are more sensitive to erosion (i.e. sand hills).
- Monitor rainfall to get an idea of what the next year's forage productivity might be.
- Use fencing for typically unused forage resources where possible, for emergency purposes.
- Stockpile any extra sources of forage, such as hay.
- Consider transportation of livestock via the most direct route to their pasture and restrict the amount of trailing to reduce disturbance of brittle vegetation and assist in the management of herd health due to reduced travel in dust.

Public health

The main public health concerns lie with three major factors: (1) the loss of the drinking water; (2) famine and malnutrition[2] and (3) possible water contamination[3]. Some of the measures that can be taken to prepare for these risks are:

- Educate public on possible water borne diseases and risks associated with drinking water as well as on having balance diets to avoid malnutrition problems.
- To treat surface water before use in case of drinking water shortages or outages.
- To closely monitor indicators of an impending famine and to establish food reserves.
- To develop a strong local food and agricultural systems, that provide an adequate fall-back resource in threatened areas.
- Develop plan for local emergency food rationing system, accompanied by public health (immunization) and primary health care (selective feeding) programs. This has to be led by a local authoritative body with a legal mandate for disaster preparation and relief.

6.2 During drought

Irrigation System Management

In addition to temporary irrigation, there are other management practices that could be exercised to reduce the risk during drought. They are listed below.

- Installation of temporary irrigation systems in case of emergency. But, they are costly, requiring hiring of additional equipment and human resources. Therefore, careful considerations should be given to water sources (the distance of the farm to nearest water sources), type of crops[4], soil types (it dictates the water carrying capacity, infiltration, and permeability), field layout and size[5], time (duration of the drought) and available budget.
- Establish an irrigation scheduling system with water released at regular intervals.
- Check all systems regularly. An improperly calibrated, clogged or leaking system can waste a great deal of water.
- Utilize recycled water, making sure they be free from oils, food scraps, etc. It can be mixed with fresh water (half and half).
- Establish irrigation zones (very low, low and moderate water zones) based on distance to and availability of water sources within the farm area. This helps determine the type of crops to be grown in what zones based on their water needs.

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[2] Due to inadequate food supplies following the low yield of crops.

[3] It could be caused by a phenomenon known as backflow, where the water or other materials from an outside source, ranging from industries and medical facilities to irrigation systems, flow back into a potable water supply and when the public has to use auxiliary or emergency sources of water to augment a primary water supply, especially use of surface water which sits idle. These can lead to water borne diseases.

[4] The type of crops currently grown can justify the costs involved. The average yearly yield increase, of crops selected to be irrigated, must be great enough to pay for the investment in irrigation and increased production costs.

[5] The layout and size of the field can influence the equipment needed (such as the horsepower of the pump and motor, etc.) and required power source necessary in determining the cost estimation.

Protecting the water sources

Water sources refer to the village or individually owned storage tanks, wells and pumps (connecting to aquifers), lakes, streams and rivers that are located nearby, as well as dams and reservoirs. Following techniques can be adopted to ensure availability of surface or sub-surface water in unusually dry seasons.

- Refrain from draining all the sloughs and wetlands over the aquifer, as these tend to be recharge areas for shallow aquifers.
- Leave a cover of residue in pasture ground. This will reduce the amount of soil surface evaporation and conserve water.
- The well should not be over-pumped.
- To reduce evaporation, construct a wind break on the banks of water bodies or install a cover for wells, storage tanks and dugouts.
- Use surface pipelines to transport water from the sources to the desired location, to eliminate evaporation. Purchase of such materials can be initiated at the village or district level rather than at individual family level.
- Monitor the performance of wells by measuring and recording water levels on a monthly or quarterly basis.

Protecting the water quality

One of the long term consequences of drought is the degradation of quality of water, which has enormous impacts on the well beings of humans as well as animals and plants. To prevent that following means can be practiced.

- Limit the direct access to water sources by livestock, by pumping to remote sites and fencing the area thereby preventing the livestock activity in the water.
- Consider use of portable stock-water supply, which may be suitable for livestock distribution on a pasture.

Emergency water supply options

There are a number of temporary options that can be employed as emergency water supply options during drought, especially in livestock and agricultural production farms.

- *Water Hauling* where water is typically hauled from neighbouring wells, deeper dugouts and nearby tank loading facilities, but often proves to be a costly and time-consuming alternative.
- *Rental of Emergency Pumping Equipment*, including irrigation type pumps and pipe for transferring water from remote water sources to depleted dugouts and reservoirs, can be rented.
- *Restoration of Inactive Water Wells* using pumping equipment and generators.
- *Installation of Portable Pipelines* to supply water to pastures and cropland that are located within a few kilometres of the water source.
- *Small Seepage Dugouts* can be used on fields where there are permanent wet areas. Prevent the contamination of water by fencing off the dugout and pumping water into a nearby water trough. Water should be tested prior to consumption.

- *Usage of wetlands and existing surface water supplies* that are almost dry and have only three or four feet of water. Similar arrangements of fencing the area and of pumping water to a separate place can be employed here as well to avoid water contamination problems.

Livestock health programs

Food and water of adequate quality and quantity are by far the most important ingredients in keeping the animals healthy. However, other factors will interact to affect an animal's susceptibility to disease during drought. These factors include:

- Stage of pregnancy or lactation. This might require higher than normal quota of feed;
- Any disease already present;
- Current immunity levels to common diseases, either through vaccination or previous exposure;
- Current parasite burdens, both internal (e.g. worms, fluke) and external (e.g. lice);
- Crowding at feeding and watering points, which may result in infectious agents, such as viruses and bacteria, concentrating in these vicinities, thereby facilitating spread;
- Congregation of potential disease carriers of other species at diminishing water sources, which may increase the risk of exposure to various diseases;
- Introduction of new feeds, which may lead to digestive upsets if not managed with sufficient care;
- Lack of green pick, which may induce the animals to eat plants that they would not normally touch, including those that are poisonous.

Because of these factors, **livestock health programs** that are recommended even in the good times are more essential during drought. Recommended practices include:

- Vaccination to prevent diseases, which are far more likely to occur in situations where there may be sudden changes in feed type, quality or quantity;
- Drench for internal parasites, especially young stock (cattle and bulls).
- Watch out for signs of malnutrition, mineral deficiency and starvation and take appropriate measures such as provision of additional protein or minerals in the feed.
- Watch out for plant poisoning.
- To separate pregnant and lactating animals from the herd so that they can be fed more.
- To introduce any change of feed slowly and mix with old feed first, gradually increasing the proportion of new feed, to reduce the chance of upsets.
- Regular check for symptoms of diseases and provide treatment immediately in consultation with the vet.
- Treat the entire herd at one time for lice infection and repeat the process at regular intervals throughout the drought period.

Managing pastures ground

Lack of adequate forage during drought can cause animals' malnutrition and, in the worst case, death. Especially in the pro-longed drought period, it is crucial to maintain the pasture ground and moderate its use, anticipating further reduction in forage availability. Some recommended methods are:

- Leave plants with some leaf area for photosynthesis to help them rebound from grazing. Leaves also shade the ground and reduce evaporation of precious soil moisture.
- Subdivide pastures into small units. This makes it possible for rotational grazing: i.e., while animals occupy one unit, other units can rest and recuperate.
- Monitor and control weed invasions.
- Be prepared to provide supplemental feed (hay or grain) when pastures are less productive.

Fire Prevention

One of the greatest danger during drought is the fire hazard, be it forest fire, urban fire or rural fire; exacerbated by the drier-than-normal air, higher-than-normal temperature and the presence of plenty of fuels (dried and dead leaves, branches, hay stacks, etc.). Therefore, it is advisable to undertake some measures to prevent frequent fire occurrences through following means:

- Clear potential fuels around houses, barns and livestock areas.
- Clear small diameter trees that have grown up in the forests.
- Put out cooking fire or fire built for any other purposes after the use. Make sure the fire is not built in close proximity to potential fuel sources.
- Establish local fire fighting groups, provide trainings (fire fighting, dissemination of fire warnings and public education, evacuation and rescue) and equip with essential tools (can be made out of locally available materials).

6.3 After drought

Community resettlement/ rehabilitation

One of two courses of actions has to be considered: re-establishment of communities in the drought-stricken area, or resettlement of the drought victims to unaffected areas. As a general rule, resettlement is not favored except in extreme circumstances or where desertification has made return to the original communities impossible. If the drought victims return to their homes, the focus is on re-establishing, and hopefully improving, normal economic and agricultural activities such as providing economic assistance to the victims, water resource development in the affected area and initiating agricultural engineering works including installation of improved irrigation systems.

Management of existing native vegetation areas and pastures

The low-cost methods of increasing and maintaining native vegetation areas, to allow them to grow to their full potential at the end of a drought are listed below.

- Delay grazing until plants become established, especially where there are young plants, by fencing the area, taking into account that the seed from large trees will fall on ground up to 50 m from the base of the trunk.
- Apply fertilizers if appropriate.
- Monitor for weed growth and pest damage.

- Keep a record of the trees and shrubs which survived best in the drought. Collect seed from these trees, which can be served as windbreaks for future drought.

7. HOW TO LESSEN FUTURE DROUGHT AND ITS IMPACTS

7.1 Rainwater harvesting

Rain water harvesting is catching rain water when it falls and storing to use during the non rainy season. Harvested rain water can be utilized for several purposes including drinking, washing, gardening, flushing etc. The water harvesting techniques are specific to the geographical and hydrological characteristics of a particular region. They can range from small scale individual/family systems (e.g., storage tanks) to medium to large scale village or community systems (e.g., community underground tanks, percolation ponds). They can also be classified as traditional and modern methods (e.g., artificial discharging of water bodies). In some countries, rain water harvesting associations have been established to carry out research and to offer advice for the most appropriate and most economical methods to be adopted by drought prone communities.

7.2 Recycling Water

Water recycling is reusing treated wastewater, most commonly used for non-potable (not for drinking) purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, cooling water for power plants and oil refineries, industrial water usage in dust control and in construction activities (concrete mixing). Recycled water can also be used indirectly for potable purposes such as recharging ground water aquifers and augmenting surface water reservoirs with recycled water.

The benefits of water recycling can be summarised as follows:

- Water recycling can decrease the diversion of water from sensitive ecosystems.
- It can provide an additional source of water.
- It can decrease wastewater discharges and reduce and prevent pollution.
- It can be used to create or enhance wetlands and riparian (stream) habitats (substances that can be pollutants when discharged to a body of water can be beneficially reused for irrigation).

Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. In uses where there is a greater chance of human exposure to the water, more treatment is required. It has to be, however, noted that the treatment of wastewater for reuse and the installation of distribution systems can be initially expensive compared to such water supply alternatives as imported water or ground water.

7.3 Water Efficiency Measures

Efficient use of water, through behavioral, operational, or equipment changes, and practiced broadly in farm and rangeland, municipalities, and rural areas can help mitigate the effects of drought on a long-term basis. Suggested methodologies are listed below.

7.3.1 Agricultural Sector

- Adopt water pricing structure that encourages efficiency.
- Provide information and education services on on-farm water management measures such as development of water reuse systems, sprinkler system, soil treatments, etc.
- Provide incentives for adoption of on-farm water efficiency measures through tax incentives, low-interest loans, equipment purchase subsidies, and water charge discounts or rebates.

7.3.2 Municipalities

- Develop and establish policies/programs encouraging efficient water use, which include offering incentive programs (rebates/tax credit) to homeowners and businesses. For instance, promotion of water-efficient landscape practices to home owners and businesses, especially those with large, irrigated properties.
- Educate and involve employees and residents in water efficiency efforts.
- Ensure that fire hydrants are tamper proof.
- Implement a water-loss management program, e.g. – establishment of a reclaimed wastewater distribution system for non-potable uses.
- Set a good example by using water efficient equipment in municipal buildings.
- Ensure the utility rate structure encourages water efficiency, or at least does not encourage water waste.

7.3.3 Commercial/ Business

- Educate and involve employees and residents in water efficiency efforts.
- Use water efficient equipment in the office buildings, such as replacement of plumbing fixtures and appliances with water-efficient models
- Detect (periodic check) and repair all leaks.
- Handle waste materials in a dry state whenever possible.
- Practice recycling of water for non-potable use.

7.3.4 Industry

- Educate and involve employees in water efficiency efforts.
- Use water efficient equipment in the buildings.
- Detect (periodic check) and repair all leaks.
- Identify discharges that may be re-used and implement re-use practices.
- Use fogging nozzles to cool products.
- Handle waste materials in a dry mode where possible.
- Turn off all flows during shutdowns. Use solenoid valves to stop the flow of water when production stops.

7.3.5 Water Efficiency Measures for Residences

Measures that can be practiced in two main areas: water usages inside the house and outside the house but within the premise of the compound, are described in the table below.

Outside the home	Inside the home
• Water plants only during the coolest part of the day (evening). It's less windy and reduces evaporation. • Water the lawn only when needed, if grass springs back after walking on it, it doesn't need watering. • Set sprinklers to water the lawn or garden and not the sidewalk. • Use a broom, not a hose, to clean driveways and sidewalks. • When washing cars, pets, etc., switch off immediately after use. Don't let the hose flow freely when not in use. Wash vehicles less often. • For swimming pool, lower pool water level to reduce amount of water splashed out and use a pool cover to reduce evaporation.	• Do not let the water run while washing dishes, use a dish pan to hold rise water. • Wash fruits and vegetables in a basin or dish pan rather than under running water. • Use a glass for rinse water when brushing teeth/shaving instead of letting the water run. • Take short showers instead of baths and consider bathing small children together. • Do not use the toilet as a trash can. • Never pour water down the drain when there may be another use for it - such as watering a plant or garden. • Check toilet, pipes and faucets regularly and repair all leaks. • Install water efficient equipment. • Use paper or recycled plates and cups to cut down on dishwashing.

7.4 Alternative crops

In case regular planting was postponed or plants do not survive because of drought, planting alternative crops (crops that require less water) during or after drought can be a good option. Some of the crops identified for such use are sunflower, soybeans and black-eyed peas. However, there are important considerations regarding this decision. They are:

- Consulting local Agricultural Department to find out which crops are suitable.
- Costing out possible added labour and other associated expenses of alternative crops, since there is no guarantee regarding the yield or quality of alternative forages.
- Identification of possible markets for alternative crops.
- Possible reduction in stored soil water for the next crop due to continual cropping.

7.5 Grants & loans

It is beneficial to do some research on whether the national or local government has special schemes on providing loan and grant for drought affected population. In some countries, systems are in place to rejuvenate particular sector (such as agriculture sector) where drought savaged farm owners are entitled to apply for financial support for re-establishment of their business or are offered lower than normal interest rates for loans. In other areas, the compensatory programs are introduced to increase production in favorable areas to make up for losses in seriously affected areas.

Drought insurance is available in developed countries for the communities (against drought induced damages to crops, livestock and other properties - by fire/wind storm/dust storm, etc.) living in drought prone areas. Nevertheless, it is useful for farm and land owners to prepare, after a drought, the followings:

- An itemized list of losses with estimate of the repair or replacement cost of each item;

- A brief history of the farm, information on farm crop base and assigned yields;
- Loan repayment plan and the schedule.

7.6 Land-Use Planning

Those lands identified as drought prone will benefit from controlled or restricted use. This requires the assessment of such land to describe the degree of its drought-prone condition, its present land use, the cyclical patterns of its land use, and land ownership. Control measures can include:

- Restricting the numbers of livestock per unit area;
- Controlling maximum population density;
- Putting a limit on amounts of water taken from public water supplies for agricultural or industrial use;
- Establishing a suitable cropping pattern that caters to extreme conditions of too much water and too little water;
- Land zonation (e.g., arid, semi-arid regions);
- Ensuring appropriate land cover (trees and shrubs) growth to prevent desertification.

A set of land-use planning recommendations needs to be linked to a program of public information to make the users of the land aware of the issues. Providing incentives will encourage the land users to comply with the controls.

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